blocked out on the inventory map, by ticking off the 40 volumes until they total the volume indicated for the first year of cut; then starting afresh for the second year of cut, and so on. Area control, or equality of size in the annual cutting area is thus subordinated. This will be approached gradually in subsequent cycles with the continued development of the forest growing stock. A closer approach to equality in the first cycle will be obtained if those major areas of the working circle bearing the heaviest stands are chosen for the starting point and the lightest areas for the final years. A logical sequence of cutting areas can be arranged easily so that the cutting at the beginning of the cycle starts at one end of the working circle and subsequent areas flow smoothly through the circle to the other end by the termination of the cycle.

At the end of the cycle, a new inventory is made, new growth rates are computed, assessment is made of the new conditions, and the regulation of cut repeated. Eventually when stocking and age of the forest has attained the desired goal, the size of the annual cut can be determined by longer periods and possibly even by rotations.

Epicormic Branching on Pruned White Fir

Richard D. Cosens
Forester, Division of Forest Management, California Forest and Range Experiment Station, Berkeley, Calif.

EPICORMIC BRANCHES have developed on white fir (*Abies concolor* (Gord & Glend.) Hoopes) one to two years after part of the live limbs were removed in a pruning experiment. The appearance of an average of six epicormic sprouts per tree raises some doubt as to the desirability of pruning this species.

Although epicormic branches are common on many tree species, the causes of sprouting are not clear. The sprouts develop from both dormant and adventitious buds. Exposure to light after thinning appears to stimulate sprout formation in some species, such as yellow-poplar.[1] On the other hand, sprouts commonly called "agony branches" develop on birch as a result of shading.[2] Sprouts are also common on injured white fir, especially where part of the crown has been lost and the bole raked by the falling of other trees. In such cases the branches appear as a feathery growth on the part of the tree where the crown was lost. Although not so obvious, a few epicormic branches are found on undamaged fir both in cut and uncut areas. Here the sprouts are generally less vigorous and often die.

Data for this study of epicormic branching were collected from two experimental plots. Both are located near Pinecrest on the Stanislaus National Forest in central California. On Plot A, 28 white fir were pruned as a part of a pathological study by Dr. W. W. Wagener and his associates of the Bureau of Plant Industry, San Francisco, Calif. The stand had been selectively logged in 1947 when approximately one-half the volume was removed. The area is of a medium site and the forest type is predominantly white and red fir with a few scattered sugar and Jeffrey pines. Diameter, crown classification, and number and position of live branches cut were recorded for each tree.

On Plot B, 50 white fir were pruned in June 1950, shortly after the commencement of the growing season. These trees were in an understocked stand of fir on land of a high site quality. The area had been logged of all merchantable trees in 1926. Borings showed that all trees pruned had been present as advance growth at the time of logging and that growth had not shown appreciable acceleration until the trees had overtopped the intermingled brush some 5 to 15 years later. Diameter, crown classification, percent of length of live crown removed, and portion of bole exposed to sunlight were recorded.

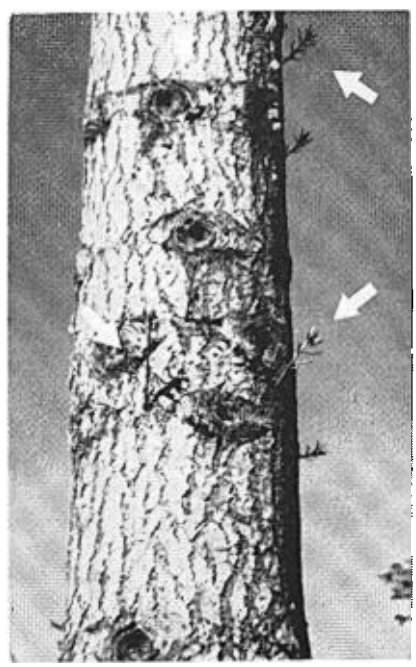

FIG. 1.—Epicormic branches in a pruned white fir. One-third of the green limbs had been removed by pruning 15 months before this photograph was taken.

An examination of the plots in September 1951 disclosed that most of the pruned trees on both areas had acquired a number of epicor-

[1] Wahlenberg, W. G. Epicormic branching of young yellow-poplar. Jour. Forestry 48:417-419. 1950.

[2] Büsgen, M. The structure and life of forest trees. Ed. rev. and enlarged by E. Münch. English translation by T. Thomson. John Wiley & Sons, Inc., New York. 1931.

mic branches (Table 1). An analysis of data from this study indicates some of the factors affecting sprout formation.

A regression analysis was made for each plot, comparing the number of sprouts per tree with growth rate, tree size, and amount of live crown removed. These factors explained only 28 percent of the variation on Plot A and 13 percent of the variation on Plot B. However, observations on unpruned trees in Plot B leave no doubt that most of the sprouts have developed as a result of pruning. It is probable that more of the variation would be explained if the plot contained trees with a smaller portion of the crown removed.

The number and position of quadrants of the pruned bole exposed to skylight were recorded on Plot B. Analysis showed that only exposure of the bole to direct sunlight, i.e., east, south, and west quadrants, had an apparent effect on the number of sprouts. Exposure of the north quadrant to skylight had no apparent effect. Trees with two or three sides (disregarding north) of the pruned bole exposed to direct sunlight had an average of 7.22 sprouts per tree, while those with one or no sides exposed had only 2.46 sprouts per tree. This was a highly significant difference as determined by the "t test." Although the number of sprouts per tree was influenced by the number of quadrants exposed to direct sunlight, there was no apparent relationship between sprout location and quadrant exposed.

These analyses give definite indications that high incidence of epicormic branching is associated with the following conditions:

1. Exposure of a large portion of the bole to sunlight as a result of pruning.
2. Small diameter of the tree at the time of pruning.
3. Rapid growth rate of the tree.
4. Removal of a large portion of the green crown.

Observations of epicormic branches on injured white fir indicate that some if not all of the sprouts will persist and grow.

TABLE 1.—DESCRIPTIVE DATA ON PRUNED WHITE FIR TREES

Item	Plot A	Plot B
Year area logged	1947	1926
Date pruned	November 1949	June 1950
Number of trees pruned	28	50
Diameter breast height when pruned	14.5 inches average (Range: 9.0-21.9)	9.2 inches average (Range: 3.8-14.9)
Diameter growth — time of pruning until September 1951	0.48 inch average (Range .2-.8)	0.70 inch average (Range .3-1.1)
Percentage of length of live crown removed	(Not recorded)	33 average (Range: 20-40)
Number of live limbs removed	11 average (Range: 2-31)	(Not recorded)
Number of pruned trees with no epicormic branches	6	5
Number of epicormic branches per tree	6 average (Range: 0-26)	6 average (Range: 0-25)

Whether more will develop on white fir if the first ones are removed is not known at his time, but observations on other sprouting species indicate that new sprouts may appear.

Epicormic branches are a serious obstacle to the production of clear lumber or peeler bolts from white fir. The species is tolerant and a notably slow natural pruner, and to defer pruning until all the branches on the prunable portion of the bole are dead would probably be uneconomical. From evidence on the plots studied, sprouts may appear on any tree from which live limbs are removed in pruning. By proper selection of the trees to prune, it may be possible to keep the number of sprouts at an allowable level. This study indicated several conditions that influenced the number of sprouts, including the size and growth rate of trees. Pruning larger, slower growing trees, however, will not yield enough clear wood to be profitable. Therefore, until a practical method of controlling sprouts is found, either by selecting trees for pruning or by subsequent removal of the sprouts, any money available for pruning may well be more profitably spent on species that do not form epicormic branches when pruned.

Journal of Forestry Subscription Rates Increased

Effective with the January 1950 issue of the JOURNAL OF FORESTRY format was changed, allowing more material to be printed in a volume and increasing the service generally to readers. An increase in subscription rates was not made at that time. However, in view of the additional service to JOURNAL readers and increased editorial, clerical, and printing costs, annual subscription rate of the JOURNAL OF FORESTRY will be increased to $7.50 annually, effective January 1953. (Additional postage, foreign $1; Canadian, 50 cents.)

Current rate of $6 annually will apply for renewal subscriptions expiring prior to December 31. Renewals and new subscriptions starting January 1953 will be billed at the new rate of $7.50 annually.